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Division of Forest Insect Investigations

TESTS WITH DDT APPLIED BY AIRPLANE FOR THE CONTROL OF PINE TIP MOTHS  
IN PONDEROSA PINE PLANTATIONS, NEBRASKA NATIONAL FOREST. 1947

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TESTS WITH DDT APPLIED BY AIRPLANE FOR THE CONTROL OF PINE TIP MOTHS  
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The pine tip moths, Hycolonia frustrana summielli and H. neomexicana have been injurious to ponderosa pine in the Nebraska National Forest throughout most of the history of those plantations. Attempts of a limited nature have been made to control these pests with various degrees of success. Biological control of H. frustrana seemed assured for a few years following the introduction in 1926 of the parasite Camponotus frustrana, but for some unknown reason the effectiveness of this parasite dissipated and it has been of little importance since. In 1945 the Forest Insect Laboratory at Fort Collins, Colorado with the assistance of the Forest Service conducted the first test to control the pine tip moths on the Nebraska Forests with DDT applied by airplane. Table 1, taken from a memorandum by H. B. Wygant dated July 23, 1945 to Dr. F. C. Craighead shows the acreage sprayed, dosages used and the results obtained. The reduction in tip moth population from this work was surprisingly good in view of the fact that the spray was applied in April, and under adverse weather conditions with rather crude equipment. In 1946 an attempt was made to control the tip moths in the Nebraska Division of the Nebraska National Forest, but unfortunately an accident with the plane made it impossible to run the test. The eggs were hatching in the field, and it would not have been possible to obtain another operator until after the larvae had entered the tips.

Table 1. Results of Aerial Application of DDT, April 1945

Plot No.	Amt. of DDT per Acre (Pounds)	Acre Sprayed	No. Trees Observed	Average No. Infested Tips Per Tree	Estimated Reduction (Percent)
1	.79	237	20	4.70	68
2	.67	48	20	7.05	50
3	.67	48	20	4.90	65
4	.67	51	20	6.70	53
Check	0		20	14.10	0
5	1.50	66	30	2.87	78
6	1.60	163	30	2.93	78
7	3.60	44	30	0.70	95
Check	0		30	12.77	0



The object of this report is to summarize the work that was done in 1947 with the aerial application of DDT at the rate of 1/2, 1 and 2 pounds of DDT per acre for control of the pine tip moths in test plots in the Niobrara Division of the Nebraska National Forest. This work was a cooperative project between the Forest Service who supplied the insecticides and part of the cost of operating the airplane; the Beltsville, Maryland laboratory of the Division of Forest Insect Investigations, who supplied the plane, equipment and pilot; and the Fort Collins, Colorado laboratory who supervised the work and supplied the ground personnel and checked the results.

### Formulation and Dosages

Approximately the same formulae of spray material, dosage, and gallonage as planned for the work in 1946, which could not be carried out, were used in the work reported herein. Much of the material had been mixed in 1946. An emulsion concentrate was prepared that contained 25 percent DDT by weight per gallon of solution as follows:

DDT	- 2 pounds
Triton X-100	- 4 ounces
151-B	- to make 1 gallon

We originally planned to use the formula of 1 pound of DDT per quart of solvent, but we found that the 151-B would not dissolve that quantity of DDT. With the revised formula 2 quarts of the emulsion concentrate was added to 2 quarts of water to give the 1 pound per acre dosage, 1 gallon to 1 gallon for the 2 pounds per acre dosage, and 1 quart to 3 quarts for the 1/2 pound per acre dosage.

As indicated in Table 2, two plots were sprayed with oil solutions. A stock solution similar to that of the emulsion concentrate with the emulsifier omitted was added to No. 2 fuel oil to give a spray solution containing 1 pound of DDT per gallon.

### Spray Application

Responsibility for the mechanics of applying the sprays in this year's tests devolved upon pilot F. R. Walker of Beltsville, Maryland. A trained forester with a good understanding of the ground as well as the aerial problems involved in spray operations of this kind, Walker was an alert and capable pilot whose work at all times was characterized by conscientious effort to apply the spray as efficiently as possible. Although the tip moth work was the first field operation he had participated in, he had had considerable previous experience in low altitude spray flights conducted in connection with equipment tests at Beltsville.

### Equipment

The plane used was an BJK-3 trainer type biplane (NR-44827) equipped with a standard 235 horsepower Wright engine, and converted for spray work. The spray apparatus consisted of a 60 gallon tank mounted in the front cockpit, a nozzle boom suspended beneath the lower wing, and a wind-driven centrifugal pump mounted on the landing gear. A relief valve mounted on the discharge side of the pump was used to regulate pressure to a constant level during spraying. Agitation of the spray liquid was accomplished by means of a bypass line carrying



the overflow from the pressure relief valve into the bottom of the tank. The boom was fitted at more or less uniform intervals with commercial spray nozzles (Spraying Systems Company, B-5) having a 1/8-inch orifice and producing a hollow cone spray pattern. The nozzles were offset below the boom and directed so that the spray was released to the rear. With this equipment the required output of both solution and emulsion type sprays for a dosage of 1 gallon per acre on a swath 2 chains wide at normal operating speed (85 mph) was 22.8 gallons per minute. Calibration flights with the pressure regulated to 26 pounds per square inch showed the number of nozzles for this output to be 26. The 2 pounds per acre dosages were applied by flying the areas twice.

### Plot Markers

The trees in the treated plantations were for the most part under 20 feet in height and were planted in east-west rows which were readily visible from the air. Alignment of the spray runs was made parallel to these rows. The swaths were marked by means of panels of yellow cloth attached to a lath framework about 1-1/2 by 3 feet in size, and mounted on a long pole. Ground personnel stationed at the beginning and end of each swath held the panels in position during the spray run, and then moved 2 chains to the center of the next swath while the pilot was circling for the succeeding flight. Had there been a visible boundary at the end of each plot, only one swath marker would have been necessary since the flight alignment was easily made by the rows of trees. Since no such boundary existed, the second marker served to indicate when the pilot had completed a swath and should shut off the spray.

### Operations

The airstrip used as a base of operations was a single dirt runway located in a large field, and was extremely rough. The jolting to which the plane was subjected in operating from this field was aggravated by the high pressure tires with which it was equipped. This severe treatment is thought to have caused excessive wear on the engine mounts, one of which was found to be badly worn when the plane returned to Beltsville. Calibration and reconnaissance flights were delayed somewhat by the hazards of crosswind takeoffs on the rough runway.

Before spray flights were undertaken both ground and aerial reconnaissance of the plots was made by the pilot. Simple signals were arranged between pilot and ground crew so that if either party desired to cease operations once the spray flights were underway, the other would be aware of the fact. Adequate attention to the preliminary details, and the whole-hearted cooperation of all concerned enabled the actual spray applications to proceed without difficulty.

### Observations and Results

The 510 acres was sprayed in about 6 hours time distributed between two mornings and one evening of flying during April 17, 18 and 19. Weather conditions prior, during and for some time after the spray was applied were wet and cold. Relatively few moths had emerged when the spray was applied and no eggs could be found. It was hoped that the DDT would kill the moths and leave enough residue to kill the young larvae if the spray failed to be toxic to the moths. After the spray was applied, a few moths of each species were placed in jars containing foliage from the plots that had been sprayed with 2 pounds of DDT per acre. These moths did not die earlier than moths on unsprayed foliage nor did they develop any of the characteristic tremors associated with insects affected by DDT.



Observations May 13-17 - W. D. Buchanan

Between April 21 and May 13 no work was done on the Niobrara Division but the following observations were made by Mr. Buchanan from May 13 to 17:

Moth flight at this time was high in both the sprayed and unsprayed plots, but no eggs, either hatched or unhatched, were seen on 9972 needles taken from a large number of trees in both sprayed and unsprayed areas. This was highly perplexing because phenological development was comparable to that in 1946 when eggs were noted at the average rate of one per each 10.86 needles on 2736 needles examined. A number of moths were collected and a great many of them were gravid females. A few of these moths placed in vials oviposited before the following day. An examination of some pine tips from unsprayed trees brought back to the Fort Collins laboratory, failed to show any evidence of eggs or larvae. However, larvae were present some place because Mr. Wygant found 6 larvae in 31 extended tips after the tips had been kept at the laboratory for 2 weeks. An examination of the tips when they were first brought to the laboratory failed to show any eggs either hatched or unhatched and no larvae were noted at that time.

On May 15, 3 plots of 15 trees each were sprayed with 1, 2 and 4 pounds of DDT per 100 gallons with a hand sprayer. The latter part of June Mr. Wygant checked these trees.

Observations June 26-29 - H. D. Wygant

The results of the application against the larvae were checked during the period of June 26 to 29, inclusive. The results were determined by counting the number of infested tips per tree on trees ranging from 5 to 6 feet high. The sample trees were taken from the center one-half of the spray plots in lines running at right angles to the line of flight. The results are indicated in the summary table below:

Table 2. Results of DDT Applied by Airplane April 17-19, 1947  
For the Control of the Pine Tip Moths, Rhyacionia Frustrana Rushnell  
and B. Neomexicana on the Niobrara Division of the Nebraska National Forest.

Dosage Per Acre	No. of Acres	No. Trees Sampled	Av. No. Infested tips per tree	Range & No. Infested Tips per tree	
				Min.	Max.
<u>1/2 lb. DDT</u>					
Emulsion 1 gal.	40	20	21.3	3	53
<u>1 lb. DDT</u>					
Emulsion 1 gal.	350	30	26.8	11	83
<u>2 lb. DDT</u>					
Emulsion 2 gals.	40	20	13.0	2	45
<u>1 lb. DDT</u>					
Oil Solution 1 gal.	40	20	22.2	6	51
<u>2 lb. DDT</u>					
Oil Solution 2 gals.	40	20	24.0	10	50
Check	—	30	36.0	14	78



The DDT appears to have had some effect on the larval population. In view of the retarded development of the insects in the spring of 1947, due to below average seasonal temperatures, it is probable that most of the DDT had disappeared by the time the eggs had hatched. The difference in the degree of control obtained in 1945 and 1947 may be due to the difference between seasons. The moths came out earlier than normal in 1945 and later than normal in 1947.

The results on the trees hand sprayed with DDT, dosages of 1, 2 and 4 pounds per 100 gallons of water, 15 trees of each dosage, show that this insecticide is toxic to the larvae. The average number of infested tips per tree receiving these treatments were 1.9, 1.1, and 1.6 respectively.

The tip moth infestation on the Bessey Division of the Forest decreased to a point in 1945 and 1946 where very little was being lost in leader growth. However, the population returned to a high level in 1947. A count of the number of tips on 30 trees infested by R. neomexicana and the first generation of R. frustrana bushnelli showed that the infestation had increased from 12.77 tips per tree in 1945 to 41.8 tips per tree in 1947. The population difference was greater than showed by the number of infested tips for many of the tips contained several larvae in 1947.

Observations September 27-28 - W. D. Buchanan

Counts made September 27 and 28 after the second brood of R. frustrana bushnelli had gone from the tips, showed that many of the 1947 tips had been killed in the trees sprayed by hand as well as those sprayed by plane or left unsprayed. In the trees sprayed at the rate of 1 pound of DDT per 100 gallons there was an average of 67.14 injured tips per tree with a range of 29 to 131; trees sprayed with 2 pounds DDT per 100 gallons had an average of 48.70 injured tips with a range of 21 to 123; those sprayed with 4 pounds of DDT per 100 gallons had an average of 36.07 injured tips with a range of 6 to 67. This makes an average of 50.33 injured tips on the hand sprayed trees. Counts made on 5 groups of 10 trees each in plots sprayed by plane and also in unsprayed areas showed an average of 40.14 injured tips per tree with a range of 7 to 77. The hand sprayed trees were somewhat larger than the others, and this accounts for some of the difference in the number of injured tips. Some of the trees have been weakened so badly that they have put out a great many very small shoots, and when a high percent of these are attacked it makes the count for those trees abnormally high. Except for the hand sprayed trees, counts were made on trees 5 to 7 feet in height.

In late June Mr. Wygant made counts on 30 trees in the Bessey Division near Balsey. At that time he found an average of 41.8 infested tips per tree. Counts in the same area (near Planting Camp #3) September 29 and 30 on 4 groups of 10 trees showed an average of 51.5 killed tips or an average of 10.3 more than had been killed by the spring attack. Many of the tips injured by the spring generation are reinfested by the second generation which results in much or all of the shoot growth of the current year being killed.

Counts made September 30 on 1-2 ponderosa pine seedlings in the Bessey Division nursery showed that there were 211 injured tips in 1689 seedlings or an average of 7.64 percent. While this percent of injured tips is not a record high it causes a deformation of the leaders and makes the seedlings unsuitable for planting stock. Also, there is danger of spreading the insect with the planting stock that is dug late in the season.



While Mr. Wygant was at the Niobrara and Bessey Division in late June making counts on the number of infested tips in sprayed and unsprayed plots, he also made collections of infested tips which he brought back to the Fort Collins laboratory and placed in 5 gallon cans. These were examined on August 27 and 28. Unfortunately molds were so bad it was difficult to make an accurate examination but from 706 tips taken from the 365 acre airplane sprayed plot it was found that 178 moths and 13 parasites had emerged. From 366 tips taken from the plot sprayed with 2 pounds DDT emulsion, 277 moths and 11 parasites emerged. In an unsprayed area in the same plantation as the above, 511 tips were collected and from these, 350 moths and 36 parasites emerged. It is quite probable that there was considerable mortality of both the larvae and parasites as the result of unfavorable conditions in the rearing cans. This is indicated by the fact that from 472 tips collected at Halsey, 406 moths and 6 parasites emerged. This material was placed in a well ventilated container and had relatively little mold in it. An examination of the parasites that emerged from all of the collections shows that Campoplex frustrana was present. There seems to be no good explanation to account for the fact that this parasite which promised to hold R. frustrana bushnellii in check a few years ago, should be more or less ineffective at present. No collections were made of the second brood of R. frustrana to determine the abundance of Campoplex. There seems little reason to believe it will regain its importance in the Nebraska plantations, and it appears that other parasites will have to be introduced if biological control is to be of much value.

#### DDT Poisoning of Cats - W. D. Buchanan

A case of what is obviously DDT poisoning of cats occurred this year at the Niobrara Ranger Station. Ranger Charley Staveley reported that his cat had 3 kittens in the barn in which we mixed the DDT solutions. The kittens were born in July, roughly 2½ months after the spray operations were completed. The mother cat and her kittens played in the barn where the DDT had been mixed and apparently got enough from the floor to injure them. This floor was flushed off with water after the spray operations were completed because some of the spray had been spilled. Ranger Staveley stated that he realized something was wrong when he saw one of the kittens lying flat on its stomach and its legs spread out on each side like a "split." Muscle spasms were severe and the kitten could not get onto its feet but would crawl along and jerk as it was moving. Mr. Staveley killed this kitten because it seemed to be suffering severely. Roughly 10 days later the other 2 kittens had spasms but they were not paralyzed as the first one was. The mother cat developed muscle spasms about 5 days after they were observed on the last 2 kittens and she apparently crawled under another building and died. The 2 kittens above were removed from the barn and placed in the house where they had overcome the muscle tremors when observed on September 28. It has been known for some time that cats are very susceptible to DDT and is mentioned here for the records.

#### Conclusions

It is known that the DDT applied in 1947 for tip moth control on ponderosa pine plantations in the Nebraska National Forest was well distributed, that it was not effective against the adults, nor was there enough residue to kill the larvae which hatched 3-4 weeks later. DDT applied with hand spray equipment just before the young larvae entered the tips gave almost perfect control. This would indicate that in order to be effective the spray must be applied about the time the eggs start to hatch.



It does not appear that the introduced parasite Campoplex frustrana nor any of the other parasites present in the Nebraska plantations can be relied upon to control the pine tip moth infestation.

#### Recommendations

In view of the fact that both the Niobrara and Bessey Divisions of the Nebraska National Forest are isolated from large bodies of timber, it appears that these plantations offer unusual opportunities for the control of tip moths through the medium of insecticides or through the introduction of parasites.

The past work shows that an accurate timing of the DDT application will be essential. In order to determine the proper time it will be necessary to have someone on the ground following the development of the insects from day to day. We believe that several days may elapse from the time eggs hatch until the larvae bore into the buds and shoots. We have not made any observations to substantiate this belief. An intensive study needs to be made of that particular phase of the habits as it has an important bearing on the timing of the spray application.

Suitable landing fields or strips for aircraft do not exist in the vicinity of either the Niobrara or Bessey Division except for a highway near Halsey that may be satisfactory. The strip that has been used at the Niobrara is nothing more than a pasture and in spite of the fact that it looks good, and has been smoothed considerably, it is still unsafe for planes to land and take off at high speeds. In dry seasons such as 1946 the sand becomes soft instead of packing when a plane or car travels over it. In view of the fact that there is no suitable landing strip sufficiently near the Niobrara plantations, it seems advisable to carry out future tests in the plantations at Halsey, Nebraska. A new, wide, hard surface road has just been completed between Theoford and Halsey which may be satisfactory for a landing strip. The old road runs parallel with the new one and traffic could be detoured onto it while spray operations are in progress.

#### Acknowledgments

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